

**System and Method for Using Shading Layers and
Highlighting to Navigate a Tree View Display**

RELATED APPLICATION

This application is related to the following co-
5 pending U.S. Patent Application filed on the same day as
the present application: "System and Method for Using Layer
Bars to Indicate Levels Within Non-Indented Tree View
Control," (Docket No. RSW920000183US1), each with the same
inventors and each assigned to the IBM Corporation.

10 **BACKGROUND OF THE INVENTION**

1. Technical Field

The present invention relates in general to a method
and system for using color and highlighting to display a
tree view display. More particularly, the present
15 invention relates to a system and method for using
different values of color and/or highlighting providing a
non-indented, layered representation of tree view data.

2. Description of the Related Art

Computer systems in general and International Business
20 Machines (IBM) compatible personal computer systems in
particular have attained widespread use for providing
computer power to many segments of today's modern society.
Systems with microprocessors are finding themselves in an
array of smaller and more specialized objects that
25 previously were largely untouched by computer technology.
These devices are sometimes called "pervasive computing
systems" because of their appearance as both traditionally

computerized devices, such as desktop computers, tower computers, and portable computers, as well as newly computerized devices such as telephones, appliances, automobiles, and other devices. Pervasive computing devices generally include a system processor and associated volatile and non-volatile memory, a display area, input means, and often interfaces, such as a network interface or modem, to other computing devices.

One of the distinguishing characteristics of these systems is the use of a system board to electrically connect these components together. Pervasive computing devices are "information handling systems" which are designed primarily to give independent computing power to a single user, or a group of users in the case of networked computing devices. Pervasive computing devices are often inexpensively priced for purchase by individuals or businesses. A pervasive computing device may also include one or more I/O devices (i.e. peripheral devices) which are coupled to the system processor and which perform specialized functions. Examples of I/O devices include modems, sound and video devices or specialized communication devices. Nonvolatile storage devices such as hard disks, CD-ROM drives and magneto-optical drives are also considered to be peripheral devices. Pervasive computing devices are often linked to computing systems and other pervasive computing devices using a network, such as a local area network (LAN), wide area network (WAN), or other type of network such as the Internet. By linking to computers including pervasive computing devices, a pervasive computing device can use resources owned by another computing device. These resources can include

files stored on nonvolatile storage devices and resources such as printers.

Pervasive computing devices are often designed to perform a specialized function that has native applications related to the function being performed. For example, a cellular telephone may be a pervasive computing device and may have a telephone directory as a native application. The telephone directory application can store names and phone numbers the user of the cellular phone wishes to store for easy retrieval. Because pervasive computing devices are often portable devices, such as a "personal digital assistant" ("PDA") or mobile telephones. As a portable device, or as a device incorporated within a larger appliance, pervasive computing devices may have constrained displays in terms of both resolution and screen size. One challenge in using devices with constrained screens is being able to navigate through layered information.

One way in which layered, or hierarchical, information is presented is by using a "tree view" control to display the information to the user. A tree view control is a window that displays a hierarchical list of items, such as the headings in a document, the entries in an index, or the files and directories on a disk. Items displayed often include a label and an optional bitmapped image, and each item can have a list of subitems associated with it. By clicking an item, the user can expand or collapse the associated list of subitems. Figure 1a shows a traditional tree view control including how items and subitems are displayed in relation to one another.

Traditional tree view window 100 shows example directories stored on a disk. Disk item 105, also called the "root directory," includes a bitmap representing a drive and a label ("Disk (c:)") corresponding to the disk.

5 Two high level directories, directory 110 ("Parent A") and directory 130 ("Parent B") are shown within the root directory. The hierarchical structure of the information is depicted by showing the directories under the root directory and indented horizontally from the horizontal position of the root directory. Likewise, subdirectories of the two high level directories are shown under the respective high level directory and further indented horizontally from the horizontal position of the parent directory. For example, child directory 115 is shown below parent directory 110 as well as indented horizontally from the horizontal starting position of parent directory 110. Similarly, child directory 135 is shown below parent directory 130 as well as indented horizontally from the horizontal starting position of parent directory 130.

20 Because any item can include subitems, the level of data shown, and the corresponding visual depth shown in the vertical and horizontal displacement, is virtually limitless.

As shown, child directory 115 has two subdirectories (grandchild directories 120 and 125) and child directory 135 has two subdirectories (grandchild directories 140 and 145). The grandchild directories, and their respective subdirectories, can have further subdirectories until all the data needed to be displayed is shown. If the horizontal displacement of a subitem is outside the window area (tree view window 100), a horizontal scroll bar is

often placed on the bottom of the window to allow the user to scroll the display to show higher level items on the left side of the window or lower level windows on the right side of the window. Scrolling between high and low level information is challenging to the user because the visual relationship between data items is weakened when only high or low level information can be seen at a given time.

This challenge is exacerbated when the resources of the pervasive computing device are constrained. For example, because of the small form factor the display is often smaller than in monitors attached to traditional desktop systems. This constraint may prevent the pervasive computing device from displaying more than one or two layers in a traditional tree view control.

What is needed, therefore, is a way to display hierarchical relationships between items in a flat tree without needing to provide horizontal displacements to communicate the level of a particular item and its relationship with other items being displayed.

RECEIVED
FEB 19 1993
FBI - NEW YORK

SUMMARY

It has been discovered that hierarchical relationships and layered data can be displayed without providing a horizontal displacement between a higher level item and a lower level subitem. Highlighting, such as color, layers of transparency, or grayscale fill, is used to visually identify items with a particular layer while virtual displacement is used to show which subitems belong to a higher level item. For example, the highest level items may be shown with a first fill color (e.g., yellow), the next, or second, level items are shown with a second fill color (e.g., orange), third level items are in turn shown with a third fill color (e.g., light blue), and fourth level items are shown with a fourth fill color (e.g., dark blue). If color is not supported on the display, shades of gray can be used instead. In addition, various shades of a particular color can be used to indicate the level of the data. For example, if the color blue is being used as the highlighting color, the most transparent use of blue as a highlight could indicate the uppermost level of the hierarchy, with less transparent, or darker shades of blue, being used to indicate lower and lower levels within the hierarchy.

When visually using the flat tree control, levels are identified by color. In the example described above, if the user sees a yellow filled item, he knows that the item is a high level item. If all the items shown are the same color then the user knows that he is looking at one layer of data. If the fill color from one item to the next changes, for example from yellow to orange, the user

understands that a level change is being shown. In the example described above, the orange item would be a subitem of the yellow item.

In another embodiment, shading is applied in an offset manner on a flat tree control structure. At least one edge of a level indicator, such as a bar or marker, is used to identify the item's level. Color and grayscale changes can be provided to further denote the level of a particular item. The horizontally displaced bars or markers enables a user to identify the layered relationships between tree view nodes even if the shading or colors between nodes is difficult to ascertain because of display limitations or the user's visual limitations.

By using color or grayscale changes to denote levels, groups of data are identified without using horizontal displacement. In addition, numeric level indicators can be provided to further note the various levels. The numeric level indicators may be well suited to environments in which the display resolution is poor or variations in shading or color is difficult to determine because of a user's visual limitations or other considerations.

Further highlighting is used to indicate attributes of a particular layer. For example, a particular fill color or shading can be used to denote the layer to which an item belongs, while a color can be added to note another attribute, such as whether an error has been found in the item, new information is located in the item, or to identify the importance of a particular item in relation to the other items within the same layer. The highlighting can be added so that the fill, or background, color

identifies an items layer with highlighting being added to the text characters comprising the item's label. Other highlighting, such as blinking, inverted text, bold text, and underlining can be used instead, or in addition to, changing an item's label color.

The foregoing is a summary and thus contains, by necessity, simplifications, generalizations, and omissions of detail; consequently, those skilled in the art will appreciate that the summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the present invention, as defined solely by the claims, will become apparent in the non-limiting detailed description set forth below.

15

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference symbols in different drawings indicates similar or identical items.

Figure 1a is a prior art depiction of a tree view control;

Figure 1b is an example of a flat tree control using grayscale fill to denote level changes;

Figure 2 is a sequence diagram showing a user expanding a grayscale flat tree control by selecting various items;

Figure 3 is a sequence diagram showing a user expanding a color flat tree control by selecting various items;

Figure 4a is a diagram of a flat tree view control with additional highlighting to emphasize item attributes;

Figure 4b is a diagram of a flat tree view control including numeric layer identifiers;

Figure 5 is a sequence diagram of a flat tree view control using layer bars superimposed on tree view item to identify the hierarchical structure;

Figure 6a is a sequence diagram of a flat tree view control using layer markers superimposed on tree view item to identify the hierarchical structure;

Figure 6b shows two flat tree view controls using various shaped layer markers superimposed on tree view item to identify the hierarchical structure;

Figure 7 is a high level flowchart showing item data
5 being retrieved and displayed in a flat tree view control;

Figure 8 is a lower level flowchart showing shading and emphasis values being applied to a tree view control node; and

Figure 9 is a block diagram of an information handling
10 system capable of implementing the present invention.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
218

DETAILED DESCRIPTION

The following is intended to provide a detailed description of an example of the invention and should not be taken to be limiting of the invention itself. Rather, any number of variations may fall within the scope of the invention which is defined in the claims following the description.

Figure 1a shows a prior art tree view control that uses horizontal item displacement to denote layers and relationship with other items (see the background discussion for a more detailed discussion of **Figure 1b**). **Figure 1b**, in comparison, shows a flat tree view display of the same data displayed in **Figure 1a**. Flat tree view window **150** is noticeably narrower than indented tree view window **100** yet displays the same information regarding item layers and relationships. Comparing the placement of items depicted in **Figure 1a** with the placement of the same items in **Figure 1b** further illustrates the flat structure of the flat tree view control shown in **Figure 1b**. High level directory **155** ("Disk (c:)"), also called the root directory for the c: hard drive, is lightly shaded and includes a disk icon accompanying the label text. The next level data, directories **160** and **180** ("Parent A" and "Parent B," respectively) are shaded slightly darker than the previous layer (directory **155**), indicating that directories **160** and **180** are subdirectories, or subitems, of directory **155**. Likewise child directories **165** and **185** are slightly darker than their respective parent directories **160** and **180**. Finally, grandchild directories **170**, **175**, **190**, and **195** are

the darkest shaded items shown, indicating that they are the lowest level directories being displayed.

Figure 2 shows a sequence diagram of a user expanding a grayscale flat tree control by selecting various items.

5 Window **200** shows a flat tree view control with multi-level expansion. Multi-level expansion allows the user to click on a high level item whereupon all the item's subitems are automatically opened (including "grandchildren," "great-grandchildren," etc.). The user uses the keyboard or a

10 selection device, such as a mouse, trackball, etc., to select an item he wishes to expand. In the example shown, the items shown in first screen **200** include root directory **205**, parent A directory **210**, parent B directory **215**, child directory **220** (a subitem of parent B directory **215**), and

15 grandchild directories **225** and **230** (both of which are subitems of child directory **220**). Icons can be used to inform the user as to whether a particular directory is opened. For example, parent B directory **215** has an open folder icon indicating that the subitems of the directory

20 are already being displayed. In contrast, parent A directory **210** has a closed folder indicating that this directory has not been opened and, therefore, any subitems within this directory are not currently displayed in window **200**. To see the contents of parent A directory **210**, the

25 user selects the directory using a pointing device or keyboard. When the user moves his pointing device, arrow **201** correspondingly moves on screen **200**. In the example shown, the user has moved arrow **201** over parent A directory **210** and selected the item, for example by clicking a button

30 located on a mouse or trackball. In a multi-level expanding application, all subitems under parent A

directory 210 are shown after when the user selects parent A directory 210. Second screen 202 shows the result of the user selecting parent A directory 210. The icon shown with parent A directory 210 is changed from a closed folder icon to an open folder icon. Beneath parent A directory 210, subitems included with the directory are visible. Child directory 235 is shown. Because the application is a multi-level expanding application, the folders within child directory 235 are also shown. In this case, grandchild directories 240 and 245 are shown beneath child directory 235. In some multi-level expanding applications, a certain number of levels (e.g., up to 3 levels) are displayed when the user selects a higher level item. In some cases, the number of subitem levels that are opened is user selectable through a configuration or setup file.

Window 250 shows the same tree view control as shown in window 200. However, in the example shown in window 250, a single-level expansion is displayed (rather than the multi-level expansion shown in window 200 and 202). In the example shown, the items shown in first screen 250 include root directory 255, parent A directory 260, parent B directory 265, child directory 270 (a subitem of parent B directory 265), and grandchild directories 275 and 280 (both of which are subitems of child directory 270). When the user selects parent A directory 260 by moving arrow 250 over the item and selecting the item, second screen 252 results. Second screen 252 shows the addition of child directory 285 under parent A directory 260. Because windows 250 and 252 show a single-level expansion example, only the next level beneath parent A directory 260 is shown. Note that the icon corresponding to parent A

directory **260** is now an open folder icon and the icon for the newly added child directory **285** is a closed folder icon. If the user selected child directory **285**, the next level below child directory **285** would be displayed (such as grandchild directories **240** and **245** shown in window **202**).

Figure 3 is a sequence diagram showing a user expanding a color flat tree control by selecting various items. Windows **300** and **302** show a multi-level expansion (similar to windows **200** and **202** in **Figure 2**) whereas windows **350**, **353**, and **354** show a single-level expansion sequence (similar to windows **250** and **252** in **Figure 2**). The items shown in **Figure 3** are similar to the items shown in **Figure 2**, however the level indication for **Figure 3** utilizes color to indicate a particular items' level. Legend **399** shows the fill patterns and the corresponding colors they represent. In the example shown, the items shown in first screen **300** include root directory **305** which would have a yellow fill color, parent A directory **310** which would have an orange fill color, child directory **315** (a subitem of parent B directory **310**) which would have a fill color of light blue, and grandchild directories **320** and **325** (both of which are subitems of child directory **315**) which would have fill color of dark blue, and parent B directory **330** which would have an orange fill color. By looking at an item's color, the user quickly understands the hierarchy of the items, which items are subitems of other items, and which items are related. The yellow filled items are the highest level, followed by orange filled items, light blue filled items, and finally dark blue items. Of course, the color used for a particular layer can be most any color and in some implementations may be specified by the user. When

the user selects parent B directory 330 using a pointing device corresponding to arrow 301, second screen 302 would be displayed. Similar to the multi-level expansion shown in Figure 2, the multi-level expansion expands multiple levels beneath parent B directory 330. In this case, second screen 302 includes child directory 335, and grandchild directories 340 and 345.

In a single-level expansion, a single level is shown beneath a selected item when the item is selected. Window 350 shows the same items as presented in window 300. However, in this example a single level, rather than multiple levels, are shown when an unexpanded level is selected. Conversely, if a previously expanded item is selected, the levels underneath the selected item are removed from the screen and the selected item's icon changes from an opened folder to an unopened folder. In window 350, the same items appear as were in window 300 (root directory 355, parent A directory 360, child directory 365, grandchild directories 370 and 375, and parent B directory 380 correspond to respective directories 305 through 330 shown in window 300). However, when parent B directory 380 is selected using arrow 351, only one additional layer underneath the selected directory is shown. In this case, child directory 385 is shown in window 353. The icon corresponding to parent B directory 380 is now shown as opened and the icon corresponding to child directory 385 is shown as unopened. When child directory 385 is selected using arrow 352, an additional layer of items underneath directory 385 appear in window 354. In this case, two additional directories, grandchild directories 390 and 395, appear.

Figure 4a is a diagram of a flat tree view control with additional highlighting to emphasize item attributes. Window **400** shows a flat tree view control with the same items as shown in window **202** in **Figure 2**. Root directory **405** is lightly shaded, parent directories **410** and **430** are the next layer under the root directory layer and are therefore slightly darker than root directory **405**. Each parent directory has a child directory, **415** and **435**, respectively, which are again slightly darker than the parent directories. Each child directory includes two grandchild directories, **420** and **425** corresponding to child directory **415**, and **440** and **445** corresponding to child directory **435**, which are the most darkly shaded items shown in window **400**. In this example, however, emphasis of particular items is shown along with the layer of the item. Color legend **449** shows the emphasis being used in the example. Grandchild directory **425** is colored red which indicates that the directory is important, while child directory **435** is yellow indicating that errors have been identified in the directory. Other emphasis highlights can be used to indicate other features or attributes of given items. In addition, while color is shown as a highlighting tool, many other highlighting tools can be used. For example, the text of the label (i.e., "Grandchild 2") can be emphasized using a color, underline, italics, or bold features. In addition, the icon can be modified to add a symbol or character indicating a condition. For instance, a red exclamation mark may indicate an important item, while a yellow question mark may indicate errors found within the particular item.

Figure 4b is a diagram of a flat tree view control including numeric layer identifiers. Some displays on pervasive computing devices may have poor contrast or color controls or may be used in light conditions in which the display screen is difficult to view. Also, some users may have visual impairments or be otherwise unable to easily distinguish between shading or color values used to indicate an item's level in comparison with other items shown on the screen. In these cases, a numerical or alphabetical level indicator can be added to provide additional visual cues to the user. In the example shown, window **450** includes the same items presented in window **400**. However, to the left of each item a numerical level indicator is displayed. Root directory **455** is shown as the first level, parent directories **460** and **480** are shown as being in the second level, child directories **465** and **485** are shown being in the third level, and grandchild directories **470**, **475**, **490**, and **495** are shown being in the fourth level. While drive and folder icons are also shown for each level, these icons could be removed to save horizontal display space, or the numeric level indicator could be included, or overlaid, on the respective icons. While the example shown is a grayscale example, the level indicators would also work on colored flat tree view displays.

Figure 5 is a sequence diagram of a flat tree view control using layer bars superimposed on tree view item to identify the hierarchical structure. In this example, a layer bar is displayed with an item to provide a horizontal displacement reference regarding the items' respective levels without shifting the displayed text. The items

displayed in window **500** are the same as the items displayed in window **200** in **Figure 2**. Root directory **505** has the longest overlay bar indicating that it is at the highest level of the hierarchy. Parent directories **510** and **515** are shown with overlay bars offset to the right from root directory **505** indicating that these directories are in the next layer of the hierarchy. Child directory **520** is shown with an overlay bar offset to the right from the parent directories indicating that this directory is in the next layer down from the parent directories. The overlay bars may be either overlaid on the text in such a fashion that the text is visible, or alternatively, the bars may be displayed as background fill with the text applied on top of the background fill. Finally, overlay bars included with grandchild directories **525** and **530** are offset from the overlay bar included with the child directory indicating that these directories are in an even lower layer of the hierarchy. When the user selects parent A directory **510** as shown by selection arrow **501**, the items beneath the parent directory are displayed. Window **502** shows the resulting display with child directory **535** and grandchild directories **540** and **545** displayed with overlay bars corresponding to their respective levels. While the shading of the items shown is kept constant and the level is indicated using the offset bar, color or different level shading (as described in **Figures 2 - 4**) can be incorporated with the offset bar to provide additional visual cues to the user regarding the relationship between items and the hierarchy of the information.

Windows **550** and **552** show an analogous situation as shown in windows **500** and **502**, except that in windows **550**

and **552** numeric level indicators are included in addition to the item names and offset bars. Window **550** shows the flat tree view control before expansion while window **552** shows the control following expansion. Root directory **555** is shown with its offset bar and a numeric indicator showing that it is the first layer of the hierarchy. Parent directories **560** and **565** are shown with the similar offset bars and a numeric indicator showing that these directories are in the second layer of the hierarchy. Child directory **570** is shown with its offset bar and a numeric indicator that it is in the third layer of the hierarchy. Finally, grandchild directories **575** and **580** are shown with similar offset bars and numeric indicators that these directories are both in the fourth layer of the hierarchy.

When the user selects parent A directory **560** using selection arrow **551**, the items beneath the parent directory are displayed, as shown in resulting display **552**. Child directory **585** is shown underneath parent A directory **560**. Child directory **585** includes an offset bar indicating that it is in the same level of the hierarchy as child directory **570** and has the same level indicator showing that it is in the third level of the hierarchy. Grandchild directories **590** and **595** are shown under child directory **585** with offset bars and level indicators showing that these directories are beneath child directory **585** in the hierarchy. Again, while the same shading is used for the offset bars, the bars can be colored or use different grayscales to further indicate the level and hierarchical relationships between items. Also, while a multi-level expansion is shown in **Figure 5**, a single-level or other type of expansion could

be used to display a single additional level or a fixed number of levels when an item is selected by the user. Furthermore, emphasis of a particular item within the tree view control can be added using the techniques described in

5 **Figure 4.**

Figure 6a is a sequence diagram of a flat tree view control using layer markers superimposed on tree view item to identify the hierarchical structure. The item information and sequencing shown in **Figure 6a** is similar to the item information shown and sequencing shown in **Figure 3**, windows **350**, **353**, and **354**. In **Figure 6a**, window **600** shows a partially expanded tree view control. Instead of horizontal bars to indicate an item's level, as shown in **Figure 5**, **Figure 6a** uses a level marker. Each marker is roughly the same size in terms of height and width with its offset used to indicate the item's level with the hierarchy. As with layer bars, markers may be overlaid on top of item text so that the text underneath is visible, or alternatively, markers may be displayed as a background fill with text displayed on top of the background fill. Root directory **605** has a level marker furthest to the left indicating that this is the highest level with the hierarchy. Parent directories **610** and **630** have level markers slightly offset to the right from the offset marker used with root directory **605**. This change in offset indicates that the parent directories are in the next level of the hierarchy underneath the root directory. Child directory **615** has a level marker further to the right from the parent directories, indicating that the child directory is in the next, or third, level of the hierarchy. Finally, grandchild directories **620** and **625** have offset markers

indicating that they are in the last, or fourth, level of the hierarchy shown. Their vertical placement underneath child directory **615** indicates that the grandchild directories shown are underneath the child directory in the hierarchy.

In this example, a single expansion is shown so that when the user selects parent B directory **630** using selection arrow **601**, any directories in the next layer of the hierarchy underneath the Parent B directory are displayed. In this case, child directory **635** is displayed in resulting window **602**. Child directory **635** has a similar offset marker as that shown for child directory **615** indicating that these directories are in the same level of the hierarchy. When child directory **635** is subsequently selected using selection arrow **636**, any subdirectories in the next layer underneath child directory **635** are displayed. In this case, resulting window **603** shows grandchild directories **640** and **645** with offset markers similar to those shown for grandchild directories **620** and **625** indicating that all grandchild directories are in the same level of the hierarchy. While the same shading is used for the offset markers, the markers and/or the underlying text can be colored or use different grayscales to further indicate the level and hierarchical relationships between items. Also, while a single-level expansion is shown in **Figure 6a**, a multi-level or other type of expansion could be used to display a all additional levels or a fixed number of levels when an item is selected by the user. Furthermore, emphasis of a particular item within the tree view control can be added using the techniques described in **Figure 4**.

Figure 6b shows two flat tree view controls using various shaped layer markers superimposed on tree view item to identify the hierarchical structure. In the example shown in **Figure 6a**, an edge of the rectangular layer marker is used to determine the level of the directory within the hierarchy. However, other shapes may readily be used to indicate the various levels of data. For example, window **650** shows upwardly-pointing triangular markers used to denote an items position within the data hierarchy. The highest level item, root directory **653** is shown with triangular marker **654** indicating its uppermost position within the hierarchy. Parent A directory **656** and Parent B directory **668** are shown with triangular markers **657** and **669**, respectively. As the next level in the hierarchy, markers **657** and **669** are shown slightly indented from uppermost triangular marker **654**. A third level of the hierarchy, illustrated by Child directory **659**, has triangular marker **660** slightly more indented than the second level markers (**657** and **669**). Finally, the lowest level directories, Grandchild directory 1 (**662**) and Grandchild directory 2 (**665**) have the most indented corresponding triangular markers (markers **663** and **666**, respectively). In window **650** and **670**, point of the marker, such as a center-point, may be used to note the level of data items with regard to other data items.

Furthermore, various shaped markers may be used to indicate a data item's level within the hierarchy. Window **670** illustrates the use of various shapes and indentations to indicate the level of the corresponding data. In window **670**, diamond-shaped markers correspond to the first level of data, rectangular-shaped markers correspond to the

second level of data, circular-shaped markers correspond to the third level of data, and triangular-shaped markers correspond to the fourth level of data. Root directory 673 has diamond-shaped marker 674 in a left-most indented position indicating that the root directory is a member of the first level of data. Parent A directory 676 and Parent B directory 688 are shown with rectangular markers 677 and 689, respectively, indicating that these directories are members of the second level of data. In addition, markers 677 and 689 are shown slightly indented from uppermost diamond-shaped marker 674. A third level of the hierarchy, illustrated by Child directory 679, has circular-shaped marker 680 slightly more indented than the second level rectangular-shaped markers (677 and 689). Finally, the lowest level directories, Grandchild directory 1 (682) and Grandchild directory 2 (685) have triangular markers (markers 683 and 686, respectively) that are the most indented markers in window 670, indicating that these directories are members of the lowest level of data.

In window 650 and 670, marker position, such as a center-point, as well as marker shape are used to note the level of data items with regard to other data items. In addition, the use of different marker shapes in window 670 can be used with or without marker indentation to note the relative level of data items within the hierarchy.

Figure 7 is a high level flowchart showing item data being retrieved and displayed in a flat tree view control. Processing commences at 700 whereupon a starting point for the tree view is received (input 705). A level number is assigned to the starting node (step 710). When a tree view is initially started, the level number would be initialized

to 0, however if the retrieved node is received as a selection from a currently displayed tree view, then the start node level would be determined by the node level of the selected item. The level number is incremented (step 5 715) and additional tree data is read for the level number (input 720). The tree data may be read from a directory table (i.e., a file allocation table), or a data file corresponding to a hierarchical set of information. The display attributes, such as shading, coloring, offset bars and markers, and numeric level indicators are included (predefined process 725, see **Figure 8** for further processing details). A determination is made as to whether additional levels of data need to be processed (decision 10 730). If additional levels of data need to be processed, decision 730 branches to "yes" branch 735 whereupon the level number is incremented (step 740), data for the next level is read (input 750), and display attributes are included (predefined process 725, see **Figure 8** for further processing details) before looping (loop 760) back to 15 decision 730. This looping continues until no more levels need to be displayed, at which time decision 730 branches to "no" branch 765 and the levels read and processed are displayed to the user (output 770) before processing ends at 775.

25 **Figure 8** is a lower level flowchart showing shading and emphasis values being applied to a tree view control node. Processing commences at 800 whereupon display parameters, or preferences, are retrieved (input 805). For example, display parameters or preferences may indicate whether 30 color or grayscale will be used to indicate levels of data, whether items are emphasized, whether offset bars or

markers are included, and whether numeric level indicators will be used. A determination is made as to whether a horizontal displacement, such as with an offset bar or marker, is included (decision 810). If horizontal displacement is included, decision 810 branches to "yes" branch 815 whereupon a shading begin point is determined based on the end point of the previous level shading coordinate (step 820). If this is the first layer in the hierarchy, then the shading begins at the left most coordinate used for shading. If a horizontal displacement is not needed, "no" branch 825 is taken bypassing the horizontal shading calculation. The next shading color or grayscale value is determined (step 830) based on the shading or color value used in the previous level. If only horizontal offset bars or marks is being used, the color or grayscale of all items may be the same. A determination is made as to whether the particular item is emphasized (decision 835). If the item is emphasized, decision 835 branches to "yes" branch 840 whereupon the emphasis highlighting preference is retrieved (input 845). This may include bolding or adding red color to important items, adding yellow highlighting to an error, etc. The retrieved emphasis is applied to the item (step 850). If no emphasis is being applied to the item, decision 835 branches to "no" branch 855 bypassing the emphasis steps. The shading or color, including any offset bars or markers, is applied to the item (step 860) so that the item's position within the hierarchy is visually indicated. Processing ends at return 890 which transfers control back to the calling routine (see Figure 7).

Figure 9 illustrates information handling system **901** which is a simplified example of a computer system capable of performing the server and client operations described herein. Computer system **901** includes processor **900** which is coupled to host bus **905**. A level two (L2) cache memory **910** is also coupled to the host bus **905**. Host-to-PCI bridge **915** is coupled to main memory **920**, includes cache memory and main memory control functions, and provides bus control to handle transfers among PCI bus **925**, processor **900**, L2 cache **910**, main memory **920**, and host bus **905**. PCI bus **925** provides an interface for a variety of devices including, for example, LAN card **930**. PCI-to-ISA bridge **935** provides bus control to handle transfers between PCI bus **925** and ISA bus **940**, universal serial bus (USB) functionality **945**, IDE device functionality **950**, power management functionality **955**, and can include other functional elements not shown, such as a real-time clock (RTC), DMA control, interrupt support, and system management bus support. Peripheral devices and input/output (I/O) devices can be attached to various interfaces **960** (e.g., parallel interface **962**, serial interface **964**, infrared (IR) interface **966**, keyboard interface **968**, mouse interface **970**, and fixed disk (HDD) **972**) coupled to ISA bus **940**. Alternatively, many I/O devices can be accommodated by a super I/O controller (not shown) attached to ISA bus **940**.

BIOS **980** is coupled to ISA bus **940**, and incorporates the necessary processor executable code for a variety of low-level system functions and system boot functions. BIOS **980** can be stored in any computer readable medium, including magnetic storage media, optical storage media,

flash memory, random access memory, read only memory, and communications media conveying signals encoding the instructions (e.g., signals from a network). In order to attach computer system 901 to another computer system to copy files over a network, LAN card 930 is coupled to PCI bus 925 and to PCI-to-ISA bridge 935. Similarly, to connect computer system 901 to an ISP to connect to the Internet using a telephone line connection, modem 975 is connected to serial port 964 and PCI-to-ISA Bridge 935.

While the computer system described in **Figure 9** is capable of executing the invention described herein, this computer system is simply one example of a computer system. Those skilled in the art will appreciate that many other computer system designs are capable of performing the invention described herein.

One of the preferred implementations of the invention is an application, namely, a set of instructions (program code) in a code module which may, for example, be resident in the random access memory of the computer. Until required by the computer, the set of instructions may be stored in another computer memory, for example, on a hard disk drive, or in removable storage such as an optical disk (for eventual use in a CD ROM) or floppy disk (for eventual use in a floppy disk drive), or downloaded via the Internet or other computer network. Thus, the present invention may be implemented as a computer program product for use in a computer. In addition, although the various methods described are conveniently implemented in a general purpose computer selectively activated or reconfigured by software, one of ordinary skill in the art would also recognize that

such methods may be carried out in hardware, in firmware, or in more specialized apparatus constructed to perform the required method steps.

While particular embodiments of the present invention
5 have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects and, therefore, the appended claims are to encompass within their scope all
10 such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those with skill in the art that if a specific number of an introduced claim element is intended, such intent will be explicitly recited
15 in the claim, and in the absence of such recitation no such limitation is present. For a non-limiting example, as an aid to understanding, the following appended claims contain usage of the introductory phrases "at least one" and "one or more" to introduce claim elements. However, the use of
20 such phrases should not be construed to imply that the introduction of a claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one
25 such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an"; the same holds true for the use in the claims of definite articles.